Microelectromechanical Systems (MEMS)

Rajeshuni Ramesham, Ph.D.
Jet Propulsion Laboratory, California Institute of Technology
4800 Oak Grove Drive, Pasadena, CA 91109
Tel.: 1 818 354 7190; Fax: 1 818 393 5245 or 4382
e-mail: Rajeshuni.Ramesham@jpl.nasa.gov

One of the newest technologies receiving significant attention in the last two decades is silicon (Si) MEMS. The foundation of MEMS is the capability of creating controllable, mechanical, moveable structures using integrated circuit processing technology. Many of the early Si sensor developments were funded by NASA. Si is widely used in the manufacture of electronic ICs, where only its electrical properties are exploited. Micromechanics takes an advantage of both the electrical and mechanical, or just the mechanical properties of Si, and thus creates a new generation of electromechanical Si chips. The key factors behind the Si sensor technology are excellent mechanical properties, batch manufacturability of mechanical structures, and available infrastructures of the IC industry. MEMS devices may have a significant application in automotive, displays, printers, fluid thrusters, analytical instruments, communications, biomedical, and aerospace industry. Operation, reliability, sensitivity, and stability of smaller, lighter, and cheaper MEMS devices is very critical in any chosen application particularly under extreme shock and ambient temperature conditions.

Hermetically Sealed MEMS Device Packages: Many high sensitivity MEMS devices need to operate in a hermetically sealed vacuum electronic package to realize their full performance. This vacuum is destroyed by out-gassing of various species such as H_2O vapor, H_2, CO, N_2, O_2, and CO_2 from the package surfaces and microleaking or permeation through the package body. The loss of vacuum is particularly serious if organic materials are used in isolated MEMS packaging device. A getter material is needed to eliminate this problem and achieve successful MEMS device operation for long duration space applications. The term "getter" refers to materials, which chemically sorb active gases in a vacuum environment. A solution is proposed using a non-evaporable high porosity getter material to solve the hermetic sealing problem associated with the microgyro for X-33 mission and other similar MEMS devices where hermetic sealing is required. The getter consists of a highly porous and mechanically stable packaging component that will be installed inside the MEMS vacuum packaging chamber and activated.

A variety of sealed-off devices such as CRT's, electron & X-ray tubes, plasma displays, particle accelerators and colliders, vacuum thermal insulation, UHV systems for semiconductor processing, lamps, FEDs require a vacuum for their successful operation. Maintaining vacuum in extremely small volume packages depends on the surface area of materials exposed to that volume that are sources for species to be outgassed and finally that will destroy the vacuum. Getters are routinely used in larger static systems and similarly getters will be needed if the desired system lifetimes of many years are to be obtained in MEMS packages for space applications.

New material such as SiC and diamond and their process technology to fabricate the MEMS devices is necessary for high temperature applications where Si may not be applicable at temperature more than 150°C. MEMS devices may have a use to monitor a wide variety of parameters such as temperature, accelerations, flow rates, pressures, vibrations, surface wear rates, fluid contaminants, position sensing, etc.

Diamond Membranes: We developed a process flow combined with photolithography and reactive ion etching of Si to fabricate diamond membranes for MEMS applications. We used reactive ion high etching rate of Si to fabricate membranes to enhance the yield of diamond microstructures. This approach is three to six times faster than the hot KOH anisotropic etching process.

Diamond Bridges and Cantilever Beams: A surface micromachining technique has been developed to fabricate diamond microstructures to facilitate application of diamond films for MEMS. Bulk micromachining means that three-dimensional features are etched into the bulk of crystalline. In contrast, surface micromachined features are built up, layer by layer, on the surface of a single crystal Si substrate. Dry etching or selective deposition defines the surface features in the x,y plane and wet etching releases them from the plane by undercutting.

Microscale movable mechanical pin joints, springs, gears, sliders, sealed cavities, and many other mechanical and optical components have been fabricated using surface micromachining of poly-silicon. Analog devices have commercialized ADXL-50, a 50-g accelerometer that was developed using surface micromachining for activating air-bag deployment. Texas Instruments' Digital Micromirror Device is also based on surface micromachining.

We developed a process flow combined with conventional photolithography and a technique of selective deposition of diamond over SiO_2/Si substrate to fabricate diamond beams and cantilever beams for MEMS applications by surface micromachining process that involves etching of SiO_2 using buffered oxide etch solution.

Acknowledgments: This research work was carried out at the JPL/Caltech and was supported by the NASA Code Q for the Office of Safety and Mission Assurance Program 323-79.